Autonomous aerial sensors for wind power meteorology - lessons learnt

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Autonomous Aerial Sensors for Wind Power Meteorology Lessons Learnt

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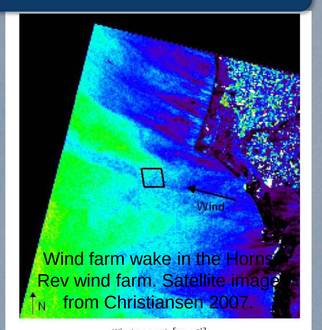
Abstract


Wakes in the Horns Rev wind farm. Image from Unifly A/S, 2009.

This poster describes a new approach for measurements in wind power meteorology using small unmanned flying platforms. Large-scale wind farms, especially offshore, need an optimisation between installed wind power density and the losses in the wind farm due to wake effects between the turbines. Good measurements of the wake and wake structure are not easy to come by, especially offshore.

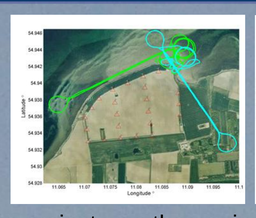
In order to test the potential and limits of UAVs for wind power meteorology, this project assembles four different UAVs from four participating groups. Risø and DELTA built a lighter-than-air (LTA) system with nano-synchronised sensors, Bergen University flies the SUMO, Tübingen University in conjunction with the TU Braunschweig flies the Carolo and MASC, and Aalborg University used a helicopter with a sonic anemometer as a slung load.

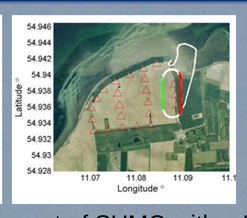
It was planned to fly all those platforms during one week at the Danish national test station for large wind turbines at Høvsøre. One of the large lessons learnt was that permitting is a major concern - both the campaign at Høvsøre and the alternate location at Risø had to be cancelled for different reasons, both related to flying permits. There was one week of flying though at the Nøjsomheds Odde wind farm in Lolland, where we could compare the SUMO and balloon with a Lidar and data from the wind farm. The other platforms performed their tests separately. Lastly, the lessons learnt were used to do a detailed planning for a possible offshore campaign.

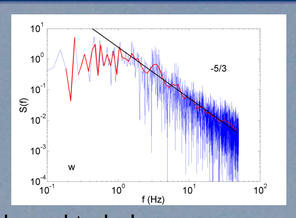


Wind farm wake in the Horns Rev wind farm. Satellite image from Christiansen 2007.

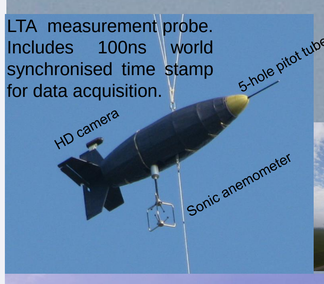
Technology



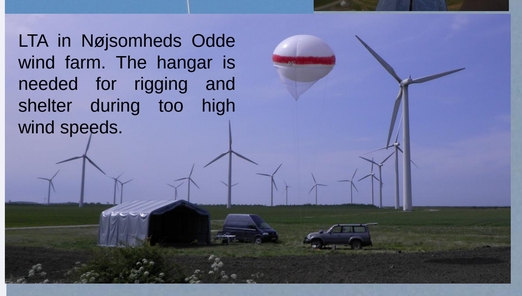




One of the technical innovations of the project was the equipment of SUMO with a 5-hole probe based turbulence measurement system and its first successful operation. The turbulence measurement system including pressure transducers and data logger is commercially available (Aeroprobe Corporation) and enables the monitoring of the 3D flow vector with a temporal resolution of 100 Hz. The figures below show from left to right, the mounting of the probe and the data logger in the fuselage of SUMO, two examples for typical flight patterns used during the campaign at the Nøjsomheds Odde wind farm in May 2011, and an example of the resulting power spectrum of the vertical flow component measured by the system.



LTA measurement probe. Includes 100ns world synchronised time stamp for data acquisition.


LTA in Nøjsomheds Odde wind farm. The hangar is needed for rigging and shelter during too high wind speeds.


Carolo (TU Braunschweig) and MASC (Uni Tübingen).


Sonic anemometer and inertial navigation system

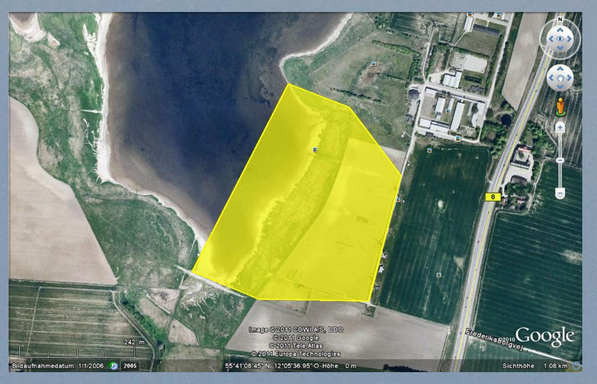
Vario XLC helicopter, 32 kg max weight, software to stabilise the slung load. Local data acquisition in sonic, including position and direction

Permitting

Primary (ideal) location: Høvsøre, the national test centre for large turbines, run by DTU. However, DTU only owns the grey roads, and overflight rights for the green fields were not given by the farmers.

Secondary location: Nøjsomheds Odde, Lolland. No fixed masts, but cooperative land and wind farm owner. 1 week of measurements with SUMO and LTA.

Final flight week planned at Risø. However, no dispensation was possible for the bird protection area in Roskilde Fjord south.



Conclusions: Legal issues have to be taken up upfront. Close collaboration with Civil Aviation Authorities is essential.

http://aerialwindsensors.risoe.dk/

Currently quite man-power intensive. All UAS need a mission controller and a safety pilot (though they might be able to control multiple planes). LTA needs two skipper, plus crew of three to erect / take down hangar.

Planes might crash, either on mission or before – have spare planes ready.

LTA was not as stable as hoped – active steering of probe might help.

Operational issues

EWEA 2012, Copenhagen, Denmark: Europe's Premier Wind Energy Event